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(54) A ringworm vaccine.

(57) A ringworm vaccine is disclosed comprising antigen isolated from at least one dermatophyte and a suitable carrier. The "antigen" can include a single antigen from a dermatophyte or a plurality of antigens as long as at least one antigen is included which will produce a sufficient immune response to confer resistance to ringworm infection upon the recipient of the vaccine. The antigen can also be isolated from more than one dermatophyte. If a preparation from more than one dermatophyte is made the antigen can include antigens which are common to all species of dermatophytes employed and/or antigens which are only specific to certain species.

A method of producing such a ringworm vaccine is also disclosed. The method comprises making an antigen preparation comprising the dermatophyte antigen described above and combining the antigen preparation with a suitable carrier.

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A RINGWORM VACCINE

FIELD OF THE INVENTION

The present invention relates to a vaccine containing antigens from parasitic organisms which cause ringworm, to methods of manufacturing such a vaccine and to the use of the vaccine for treating patients infected with ringworm.

BACKGROUND OF THE INVENTION

Humans and other mammals, including many types of domesticated animals from dairy cattle to the family cat, are plagued by ringworm (dermatomycosis) which is caused by infection by one or more of a number of parasitic fungi generically called "dermatophytes" (i.e., organisms which upon infection cause ringworm). Dermatophytes include without limitation the species listed in Table I.

Table I

Dermatophytes and Hosts	
Dermatophyte	Host(s)
Epidermophyton floccusum	man
Miscrosporum audouini	man (children), dogs, monkeys
Microsporum canis	dogs, cats, man, sheep, monkeys, swine
Microsporum distortum	monkeys, dogs
Microsporum equinum	horses
Microsporum gypseum (gypsum)	man, dogs, cats, horses
Microsporum nanum	swine
Trichophyton concentricum	man
Trichophyton equinum	man (children), horses
Trichophyton gallinae	poultry, man
trichophyton gypsum (gypseum)	sheep
Trichophyton megnini	man, cattle
Trichophyton mentagrophytes	mice, rats, muskrats, chinchillas, cattle, man, horses, sheep, dogs, cats, swine, goats, rabbits, guinea pigs
Trichophyton quinckeanum (quinkeanum)	man, horses, sheep
Trichophyton rubrum	dogs, swine, foxes, primates, mice, squirrels, muskrats, etc.s
Trichophyton schoenleini	man, cats, mice, rats, rabbits
Trichophyton tonsurans	man
Trichophyton verrucosum	cattle, man, horses, dogs, sheep
Trichophyton verrucosum var. album	cattle
Trichophyton verrucosum var. discoides	cattle, swine
Trichophyton verrucosum var. ochraceum	sheep
Triphophyton violaceum	man

Extensive additional information relating to dermatophytes and dermatophyte mycology can be found in "*The Medical Mycology Handbook*" by Campbell and Stewart (John Wiley & Sons, 1980) (hereinafter the "Campbell/Stewart Handbook"), which is incorporated herein by reference as if fully set forth.

Ringworm usually manifests itself as a series of rapidly expanding, imitating lesions which can occur in

any area of the skin. Dermatophytes attack chiefly keratinized tissues, particularly the stratum corneum and hair fibers resulting in autolysis of the fiber structure, breaking off of the hair and alopecia. Exudation from invaded epithelial layers, epithelial debris and fungal hyphae produce the dry crusts characteristic of the disease. The lesions progress if suitable environmental conditions for mycelial growth exist, including a warm humid atmosphere, and a slightly alkaline pH of the skin. Dermatophytes are all strict aerobes and the fungi die out under the crust in the center of most lesions leaving only the periphery active. It is this mode of growth which produces the centrifugal progression and the characteristic ring form of the lesions (hence "ring-worm"). Secondary bacterial invasion of hair follicles and other tissues is also commonly associated with ringworm infection.

Many common ailments are actually dermatophyte infections. *Tinea pedis* (athlete's foot or ringworm of the feet) is associated with *Epidermophyton floccusum* various species of *Trichophyton* and, rarely, species of *Microsporum* and other fungi. *Tinea unguium* (ringworm of the nails) is caused by *Trichophyton rubrum. Tinea cruris* ("jock itch" of ringworm of the groin) results from infection with *Epidermophyton floccusum* and species of *Trichophyton. Tinea corporis* (ringworm of the body) is caused by various species of *Trichophyton* and *Microsporum*, involves the smooth and hairless skin and results in either simple scaling or deep granulomas. *Tinea imbricata* (scaly ringworm) is a disease of the tropics and is apparently caused by a single fungus, *Trichophyton concentricum. Tinea barbae* (barber's itch or ringworm of the beard) is caused by various species of *Trichophyton* and *Microsporum. Tinea capitis* - (ringworm of the scalp and hair) is most common in children but may affect adults. The causative organisms, vartous species of *Trichophyton* and *Microsporum*, may be acquired by contact with infected animals or children. *Microsporum audouini* is most commonly involved but *Microsporum canis* and *Microsporum gypsum (gypseum)* produce deeper, more severe lesions. *Trichophyton tonsurans* is also known to produce widespread infections in the scalp.

To date, the ringworm problem has, for the most part, been handled by post-infection treatment because an effective vaccine has not been available. The significance of stun pH in the development of ringworm is widely known. The susceptibility of humans to ringworm is much greater before puberty than afterwards when the stun pH falls from about 6.5 to about 4.0. This change is largely due to excretion of fatty acids in the sebum and these fatty acids are often highly fungistatic. For this reason, various kinds of topically-applied agents have been used to kill the infecting fungus and relieve the condition. Many treatments for ringworm are based upon alteration of stun pH by topically applying various agents (e.g., propionic acid, undecylenic acid). Other ringworm therapies have relied upon other topically applied commercially available products such as Conofite and Captan. Orally-administered agents (e.g., Griseofulvin and Ketoconazole] are also available.

Unfortunately, however, post-infection treatment cannot completely prevent in many instances. Once therapy is discontinued, reinfection usually occurs. It would therefore be desirable to provide a vaccine for ringworm to prevent infection before these adverse effects are suffered. One of the objects of the present invention is to provide such a vaccine.

SUMMARY OF THE INVENTION

In accordance with the present invention, a ringworm vaccine is disclosed comprising antigen from at least one dermatophyte and a suitable carrier. The "antigen" can include a single antigen from a dermatophyte or a plurality of antigens as long as at least one antigen is included which will produce a sufficient immune response to confer resistance to ringworm infection upon the recipient of the vaccine. The antigen can also be from more than one dermatophyte. If a preparation from more than one dermatophyte is made the antigen can include antigens which are common to all species of dermatophytes employed and/or antigens which are only specific to certain species. The antigen can be "from a dermatophyte" in that it has at least one epitope which is immunologically identical to or cross-reactive with an epitope which is found in the structure of a dermatophyte or in the structure of substances produced by the dermatophyte during infection (e.g., toxins which are produced and/or secreted by the organism during infection).

Suitable carriers for administration of vaccines are well known in the art and can include buffers, gels, microparticles, implantable solids, solvents, other adjuvants or any other means by which the antigen of the vaccine can be introduced into a patient and be made sufficiently available to produce an immune response to the antigen. In the preferred embodiments of the present invention the carrier is a lactose-containing solution of Lactated Ringers Solution (or other isotonic solution), aluminum hydroxide gel and formaldehyde. Formaldehyde is added to the preferred embodiments to serve as an agent that will kill dermatophytes and

prevent contamination of non-specific fungus or bacteria. Other such agents can also be employed in formulating antigen preparations and vaccines of the present invention.

A method of producing such a ringworm vaccine is also disclosed. The method comprises making an antigen preparation comprising the dermatophyte antigen described above and combining the antigen preparation with a suitable carrier. The antigen preparation can be prepared by any available means for obtaining antigen in a form which can be added to the carrier. Antigen can be isolated for use in such preparations by any available means, including without limitation homogenization of dermatophytes or portions of dermatophytes, fractionation of dermatophyte preparations, production of dermatophyte antigen by recombinant DNA technology, isolation of dermatophyte secretions and culturing of material from ringworm lesions. In the preferred embodiments of the present invention, the antigen preparation is made from homogenized cultures of appropriate dermatophytes. Preferably, all the dermatophytes in the culture are killed before the culture is homogenized leg., by the addition of formaldehyde or other agent which kills dermatophytes). The preferred embodiments also aspirate or filter the homogenized culture before it is added to the carrier. Finally, the antigen preparation is added to the carrier such that antigen is present in a concentration sufficient to produce an immune response and/or confer resistance upon administration of the vaccine to a patient.

The vaccine of the present invention and vaccines produced according to the method of the present invention can be used for the treatment of a patient for the purpose of producing immunity to ringworm infection e.g., prophy'actic treatment) or for the purpose of irradicating existing infection. Such patient can be a mammal of any species which is susceptible to infection by dermatophytes. Furthermore a pregnant patient can be treated with such vaccines such that the progeny of the pregnancy exhibit resistance to ringworm infection at birth.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Samples of various dermatophytes are available from commercial supply houses (e.g., Difco, Gibco). Cultures of *Microsporum canis*, *Microsporum gypsum* and *Trichophyton mentagrophytes* have also been deposited by applicants with ATCC pursuant to the Budapest treaty as accession numbers ATCC , ATCC and ATCC , respectively. Methods of isolating various dermatophytes are also well known to the art and can be found in the Campbell/Stewart Handbook.

The following examples are illustrative of the present invention in certain preferred embodiments. The scope of the present invention is not, however, limited to these examples and is defined by the terms of the claims appended hereto.

Example 1

Sabouraud's Dextrose Broth ("SDB") and Sabouraud's Dextrose ("SD") plates were obtained from Difco, Gibco and DiMed (St. Paul, Minesota). SDB is a broth that contains neopeptone and bacto-dextrose in a proportion of 1:4. SD agar contains neopeptone, bacto-dextrose and agar in proportions of 2:8:3. SDB and SD agar for plates can also be prepared according to the recipes found on pages 384-85 of the Campbell/Stewart Handbook.

Separate samples of *Microsporum canis*, *Microsporum gypsum* and *Alternaria sp.* (a fungus which does not cause ringworm) were isolated from a human (who had been infected by an infected cat), cattle and cattle, respectively, as follows: A ringworm lesion containing the desired fungus was washed with 70% alcohol solution and allowed to air dry. The surface of the lesion was then scraped with a scalpel to remove some of the infected tissue. The scrapings were then placed in SDB and cultured. After significant growth was observed, a sample from each culture was plated on SD plates to check the purity of the culture. Pure cultures were then used as inocula as described below.

Microsporum canis, *Microsporum gypsum* and *Alternaria sp.* were each used to inoculate a separate 10ml vial containing SDB. The three vials were then incubated at room temperature for 4 days. Each vial was shaken vigorously once during each day of culture.

The contents of each vial was then added to a separate ordinary 400ml growth chamber (commercially available from Corning) containing 90ml SDB. The chambers were then grown at room temperature until maximum growth (i.e., no increase from previous day measured by eye) was reached. The chambers were

shaken vigorously once during each day of culture. When maximum growth was reached, a sample from each chamber was plated onto SD plates to check the purity of the cultures. Maximum growth for *Microsporum canis, Microsporum gypsum* and *Alternaria sp.* was found to be approximately 4 days, 7 days and 4 days, respectively.

Once the cultures were determined to be pure, formaldehyde diluted with Lactated Ringers Solution was added to each chamber such that the final concentration of formaldehyde in each chamber was 0.2% in a total volume of 400ml. The cultures were then allowed to sit for 4 days. Cultures were plated onto SD plates to see if all fungi had been killed.

Once all fungi were killed, cultures of *Microsporum canis, Microsporum gypsum* and *Alternaria sp.* were separately homogenized using an Oster blender for 2-5 minutes on a low setting, taking care such that the blender did not overheat and heat the homogenized cultures. The homogenized cultures were then allowed to stand for approximately 48 hours.

Each homogenized culture was then aspirated through a Whatman 4 filter. The aspirates from all three organisms were then combined. 72ml of aluminum hydroxide/methylcellulose gel (commercially available from Barre) or equivalent was added as a standard adjuvant and the mixture was brought up to a final volume of 3600ml with Lactated Ringers Solution to produce the final vaccine.

5ml of the final vaccine was administered to cattle on several farms. Depending on the farm, 50-100% of the cattle treated were cured of pre-existing ringworm infection and exhibited resistance to reinfection after treatment. Those infections not succumbing to treatment with the vaccine were probably caused by infecting organisms not included in the vaccine (i.e. other than *Microsporum canis* or *Microsporum gypsum*).

1ml of the final vaccine was also administered to cats. The cats treated exhibited resistance to ringworm infection up to 18 months after administration of the vaccine.

Example 2

A vaccine was prepared from *Microsporum canis, Microsporum gypsum* and *Trichophyton mentagrophytes* using the procedure described in Example 1.

5ml of the final vaccine was administered to cattle. As of the filing date of this application, all cattle treated have exhibited continued resistance to ringworm infection for a period of up to 7 months.

Example 3

A sample of *Microsporum canis* was isolated as described in Example 1. The sample was then used to inoculate a 10ml vial containing SDB. The vial was incubated for 4 days at 95° F, shaking the vial vigorously once during each day of culturing.

The contents of the vial was then added to a growth chamber containing 90ml SDB. The growth chamber was incubated until maximum growth was reached at 35° C (95° F), shaking the chamber vigorously once during each day of culturing. When maximum growth was reached (approximately 4 days), a sample from the chamber was plated onto SD plates to check the purity of the culture.

Once the culture was determined to be pure, formaldehyde diluted with Lactated Ringers Solution was added to the chamber such that the final concentration of formaldehyde in the chamber was 0.2% in a total volume of 400ml. The culture was then allowed to sit for 4 days. The culture was plated onto SD plates to see if all fungi had been killed.

Once all fungi were killed, the culture was homogenized using an Oster blender for 5 minutes on a low setting, taking care such that the blender did not overheat and heat the homogenized culture. The homogenized cultures were then allowed to stand for approximately 48 hours.

The homogenized culture was then aspirated through a Whatman 4 filter. Formaldehyde, aluminum hydroxide gel and Lactated Ringers Solution were added to the homogenized culture such that the final concentration of formaldehyde and aluminum hydroxide gel in a total volume of 3000-4000ml was 0.2% and 2%, respectively. This solution was the final vaccine.

Cats were treated with the final vaccine in varying doses depending on the age of the cat. Adult cats received 1ml. 5-7 week kittens received 0.25ml and 9 week kittens received 0.5ml. Approximately 95% of the cats treated exhibited resistance to ringworm infection for (as of the filing of this application) up to 8

months. Administration of this final vaccine to a pregnant cat was also observed to confer resistance to infection upon the progeny of the pregnancy for a period of approximately 4-5 weeks. No adverse effects were observed with respect to the pregnancy or the progeny.

Example 4

Four homogenized and aspirated cultures were prepared from *Microsporum canis*, *Microsporum gypsum* and *Trichophyton mentagrophytes* according to the procedure described in Example 3. The aspirates were then combined with each other and with formaldehyde, aluminum hydroxide gel and Lactated Ringers Solution such that the final concentration of formaldehyde and aluminum hydroxide gel in a total volume of 4000ml was 0.2% and 2%, respectively. This solution was the final vaccine.

5ml was administered to cattle. All cattle treated exhibited resistance to ringworm infection for (as of the filing of this application) up to 8 months.

Claims

1. A ringworm vaccine comprising:
antigen from at least one dermatophyte; and a suitable carrier.

2. The vaccine of claim 1 wherein the antigen is from at least one of the following dermatophytes:
Epidermophyton floccusum
Microsporum audouini
Microsporum canis
Microsporum distortum
Microsporum equinum
Microsporum gypseum (gypsum)
Microsporum nanum
Trichophyton concentricum
Trichophyton equinum
Trichophyton gallinae
Trichophyton gypsum (gypseum)
Trichophyton megnini
Trichophyton mentagrophytes
Trichophyton quinckeanum (quinkeanum)
Trichophyton rubrum
Trichophyton schoenleini
Trichophyton tonsurans
Trichophyton verrucosum
Trichophyton verrucosum var. album
Trichophyton verrucosum var. discoides
Trichophyton verrucosum var. ochraceum
Trichophyton violaceum.

3. The vaccine according to claim 1 or 2 wherein the antigen is from Microsporum canis.

4. The vaccine according to claim 1 or 2 wherein the antigen is from Microsporum canis, Microsporum gypsum and Trichophyton mentagrophytes.

5. The vaccine according to any one of claims 1 to 4 wherein the carrier comprises aluminum hydroxide gel or an isotonic solution.

6. The vaccine of claims 1 to 5 wherein the carrier comprises Lactated Ringers Solution.

7. The vaccine according to any one of claims 1 to 6, further comprising an agent which will kill dermatophytes or prevent contamination of non-specific fungus or bacteria.

8. The vaccine according to claim 7 wherein the agent is formaldehyde.

9. A method of producing a ringworm vaccine, comprising:
making an antigen preparation comprising an antigen from at least one dermatophyte; and
combining this antigen preparation with a suitable carrier.

10. The method according to claim 9 wherein the antigen preparation is made by procedures comprising homogenizing a culture of the at least one dermatophyte, which optionally has been added

before homogenization with an agent which will kill dermatophytes or prevent contamination of non-specific fungus or bacteria, and after homogenization aspirating the culture through a filter.

11. The method according to claim 9 or 10 wherein the agent is formaldehyde.

12. The method according to any one of claims 9 to 11 wherein the dermatophyte is selected from at least one of

Epidermophyton floccusum
Microsporum audouini
Microsporum canis
Microsporum distortum
Microsporum equinum
Microsporum gypseum (gypsum)
Microsporum nanum
Trichophyton concentricum
Trichophyton equinum
Trichophyton gallinae
Trichophyton gypsum (gypseum)
Trichophyton megnini
Trichophyton mentagrophytes
Trichophyton quinckeanum (quinkeanum)
Trichophyton rubrum
Trichophyton schoenleini
Trichophyton tonsurans
Trichophyton verrucosum
Trichophyton verrucosum var. album
Trichophyton verrucosum var. discoides
Trichophyton verrucosum var. ochraceum
Trichophyton violaceum.

13. The method according to any one of claims 9 to 12 wherein the dermatophyte is Microsporum canis.

14. The method according to any one of claims 9 to 12 wherein the dermatophytes are Microsporum canis, Microsporum gypsum and Trichophyton mentagrophytes.

15. The method according to any one of claims 9 to 14 wherein the carrier comprises aluminum hydroxide gel or an isotonic solution.

16. The method according to claim 15 wherein the carrier comprises Lactated Ringers Solution.

17. Use of the ringworm vaccine according to any one of claims 1 to 8 to produce immunity and/or confer resistance to ringworm infection.

European Patent Office

PARTIAL EUROPEAN SEARCH REPORT

which under Rule 45 of the European Patent Convention shall be considered, for the purposes of subsequent proceedings, as the European search report

Application number
EP 90 10 5356

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl.4)
X	GB-A-1 548 436 (VSESOJUZNY INSTITUT EXPERIMENTALNOI VETERINARII)		A 61 K 39/00
	* Page 1, lines 41-70; page 2, lines 13-122 *	1,2	
Y		5-17	
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X	COMMONWEALTH AGRICULTURAL BUREAU, ref 0I039-00000; 0V042-00762; A.I. PODOBEDOV: "Specific prophylaxis of cattle ringworm (using live trichophyton faviforme antigen" & VETERINARIYA (Moscow) 1971, (no.6): 48-49		
	* Abstract *	1,2,9	
Y		5-17	
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			TECHNICAL FIELDS SEARCHED (Int. Cl.4)
	./.		A 61 K

INCOMPLETE SEARCH

The Search Division considers that the present European patent application does not comply with the provisions of the European Patent Convention to such an extent that it is not possible to carry out a meaningful search into the state of the art on the basis of some of the claims.

Claims searched completely: 1-16

Claims searched incompletely:

Claims not searched: 17

Reason for the limitation of the search:

Method for treatment of the human or animal body by surgery or therapy (see Art. 52(4) of the European Patent Convention).

Place of search	Date of completion of the search	Examiner
THE HAGUE	17-05-1990	REMPP

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
Y : particularly relevant if combined with another document of the same category
A : technological background
O : non-written disclosure
P : intermediate document

T : theory or principle underlying the invention
E : earlier patent document, but published on, or after the filing date
D : document cited in the application
L : document cited for other reasons

& : member of the same patent family, corresponding document

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DOCUMENTS CONSIDERED TO BE RELEVANT			CLASSIFICATION OF THE APPLICATION (Int Cl 4)
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	
X	MEDLINE, abstract no. 83219193; Z. HUSSIN et al.: "Vaccination procedures and the infectivity of dermatophyte lesions" & MYCOPATHOLOGIA Feb 17, 1983, 81 (2), p71-6 * Abstract *	1,2	
Y		5-17	
	----		TECHNICAL FIELDS SEARCHED (Int Cl 4)